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Development of Infundibular Obstruction After Percutaneous Pulmonary Balloon Valvuloplasty

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A 14 month old boy with suprasystemic right ventricular pressure secondary to pulmonary valvular stenosis and anular size of 10 mm underwent percutaneous balloon valvuloplasty with a 12 mm balloon. Right ventricular pressure almost doubled after valvuloplasty and the electrocardiogram revealed development of severe right ventricular strain. Both findings persisted on the following day. A postvalvuloplasty right ventriculogram demonstrated a severe systolic infundibular obstruction not present before. The patient underwent surgical relief of infundibular obstruction; successful opening of the pulmonary valve by the balloon valvuloplasty was observed.

It is concluded that a balloon size 20% larger than anular size can be safe in human subjects and that infundibular obstruction may appear or even worsen after balloon valvuloplasty. Such an obstruction may be related to the severity of pulmonary valvular obstruction and a hypercontractile infundibulum.

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Percutaneous pulmonary balloon valvuloplasty has been established recently as a safe and effective method of relieving pulmonary valvular stenosis (1–7). In most of the patients undergoing pulmonary balloon valvuloplasty, the right ventricular pressure has been reduced significantly when successful tear of the pulmonary valve leaflets has been achieved, usually immediately after the procedure. To our knowledge, there has been no report of a worsening hemodynamic profile after successful opening of the pulmonary valve orifice. This report describes the development, after a successful pulmonary balloon valvuloplasty, of an acute and severe increase in right ventricular pressure and right ventricular strain secondary to a hypercontractile infundibulum.

Case Presentation

A 14 month old boy underwent cardiac catheterization for evaluation and treatment of severe pulmonary valvular stenosis. He had been growing and developing well without cyanotic or syncopal episodes. The physical examination, chest roentgenogram and electrocardiogram were all consistent with severe pulmonary valvular stenosis.

The echocardiogram demonstrated right ventricular hypertrophy with a thickened and abnormal pulmonary valve and a very abnormal flow pattern by pulsed Doppler recording in the pulmonary artery. The pulmonary anular diameter measured 11 mm in the short parasternal and long-axis right ventricular views and the infundibular area was not found to be obstructive.

On cardiac catheterization, a suprasystemic right ventricular pressure of 105 mm Hg was found, compared with a simultaneous peak systolic aortic pressure of 80 mm Hg. The pulmonary valve was uniformly thickened and domed and poststenotic dilation of the main pulmonary artery was present (Fig. 1A and B). The pulmonary valve anulus measured 10 mm in diameter in both the anteroposterior and lateral projections. The infundibular region was not considered to be severely obstructive even at maximal systole, and the infundibular to anular diameter ratio in systole on the lateral view was calculated to be 0.7 (Fig. 1A and B).

Pulmonary valvuloplasty. A 12 mm balloon angioplasty catheter (Meditech) was used for the valvuloplasty, with balloon pressures ranging between 4.5 and 5 atmospheres. The valvuloplasty procedure was repeated five times, although disappearance of the balloon waist was seen on first inflation. A repeat measurement of right ventricular pressures immediately after the procedure showed an in-

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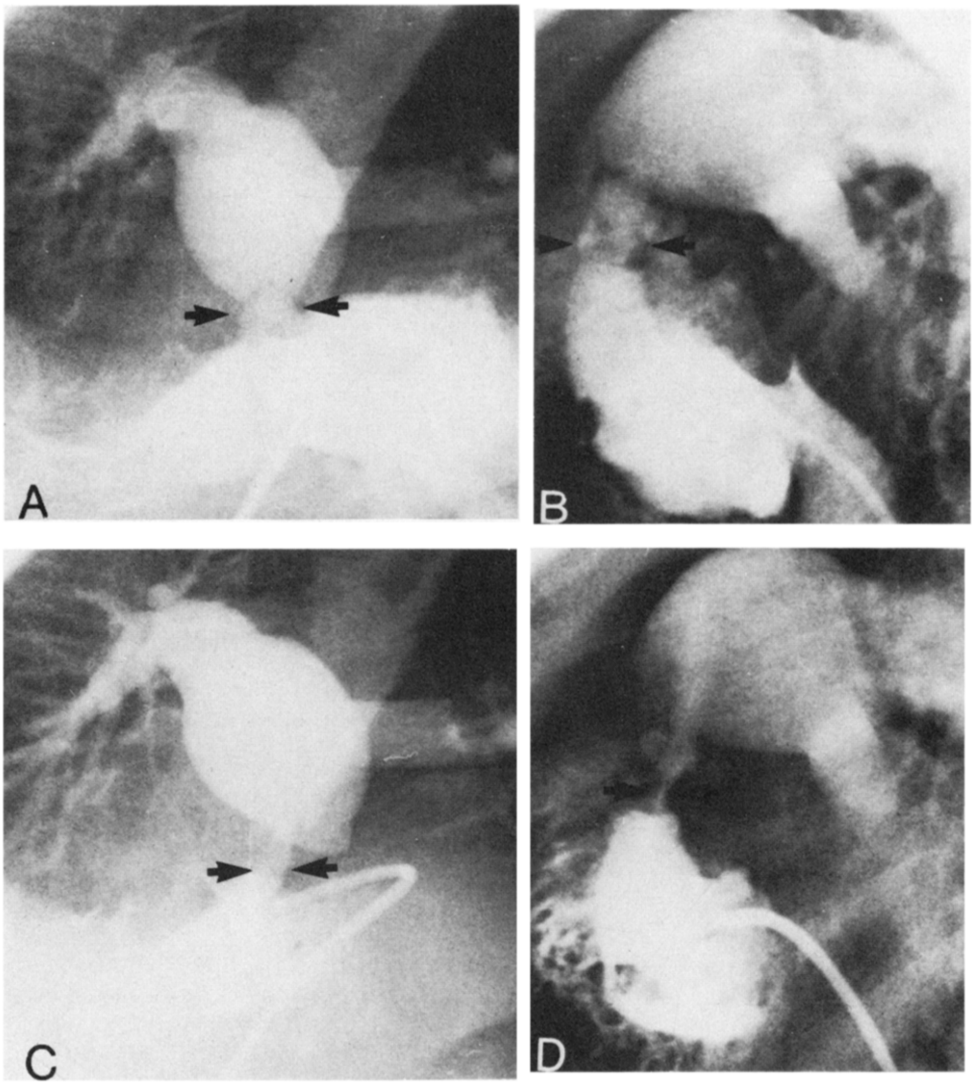

Figure 1. Right ventriculograms in the anteroposterior (**A and C**) and lateral (**B and D**) projections at peak systole. **A and B,** Before valvuloplasty. The infundibulum (**arrows**) is widely patent and is about three-quarters of the anular diameter. Note the poststenotic dilation of the main pulmonary artery. **C and D,** After valvuloplasty. There is an almost complete collapse of the infundibulum (**arrows**).

creased right ventricular peak systolic pressure of 180 mm Hg.

Repeat cardiac catheterization the following day showed a peak systolic right ventricular pressure of 214 mm Hg. A review of the postvalvuloplasty right ventriculogram demonstrated free motion of the pulmonary valve. The infundibular region, however, was much narrower than before the valvuloplasty, with almost complete obstruction at peak systole (Fig. 1C and D).

The electrocardiogram after the valvuloplasty demonstrated new ST depression of 1.5 mm over the right and middle precordial leads that persisted on the following day.

Surgical observations. The patient was taken to surgery for infundibulectomy and right ventricular outflow tract reconstruction. Inspection of the pulmonary valve showed a tricuspid pulmonary valve that had been fully opened by the valvuloplasty procedure. There were two tears down to the anular region, each closely adjacent to a commissure. The pulmonary artery and the right ventricular outflow tract areas were undamaged except for a 2 × 3 mm subendocardial hemorrhage immediately underneath a pulmonary valve cusp.

Discussion

Balloon size and safety. The use of percutaneous pulmonary balloon valvuloplasty has recently become effective and safe in the treatment of congenital pulmonary valvular stenosis (1–7). No mortality has been reported and the morbidity has been minimal. In many patients, the balloon used was the size of the pulmonary valve anulus. It has been suggested from balloon dilation of other congenital lesions (8–12) that a balloon diameter larger than the pulmonary valve anulus might improve hemodynamic results. Overdilation of the pulmonary valve anulus in the lamb showed that a balloon diameter 20 to 40% larger than the diameter of the pulmonary valve anulus caused only minimal cardiac trauma (13). Our patient's valve was dilated by a balloon

with a diameter 20% larger than the diameter of the pulmonary valve anulus; the procedure caused only minimal damage to the subvalvular region and adequate opening of the pulmonary valve as observed during surgery. These observations suggest that a balloon diameter 20% larger than the diameter of the pulmonary valve anulus may possibly be used safely in patients.

Subpulmonary obstruction. In most of the patients undergoing percutaneous pulmonary balloon valvuloplasty, a significant decrease in the right ventricular pressure has been observed, even in patients with systemic and suprasystemic right ventricular pressures before the procedure (4,5). In these series, only one patient with systemic right ventricular pressure and no infundibular obstruction on the prevalvuloplasty study developed an infundibular gradient after valvuloplasty (4). There has been no report, however, of increasing right ventricular pressure secondary to unmasking of an infundibular obstruction by pulmonary balloon valvuloplasty as has been demonstrated in our patient.

A similar phenomenon of infundibular obstruction, although to a much lesser extent, has been observed after surgical valvulotomy (14–17), and has been shown to regress spontaneously with time. When the infundibular to anular diameter ratio was used as measured from the lateral projection of the right ventriculogram at peak systole, a correlation was found between this ratio and the right ventricular pressures (16,17). However, this ratio could not predict which patients might fail to resolve a secondary infundibular obstruction. In our patient, a prevalvuloplasty infundibular to anular diameter ratio of 0.7 did not suggest the development of such a severe postvalvuloplasty infundibular obstruction as we observed. The acute increase in right ventricular pressure in our patient was found to complicate a successful pulmonary balloon valvuloplasty. This increase in the right ventricular pressure could not be predicted before the valvuloplasty. It is conceivable that such an exaggerated infundibular response was generated by a hypercontractile right ventricle.

Clinical significance. We speculate that a few of the patients with suprasystemic right ventricular pressure may respond to pulmonary balloon valvuloplasty with increasing infundibular obstruction. These patients may not be identifiable by the prevalvuloplasty studies. We suggest that in patients with suprasystemic and systemic right ventricular pressures before valvuloplasty, a repeat pressure measurement and right ventriculogram after the procedure and a repeat electrocardiogram the following day may identify those patients in whom subpulmonary obstruction may develop acutely to dangerous levels.

References

1. Semb BKH, Tjonneland S, Stake G, Aabyholm G. Balloon valvulotomy of congenital valvar stenosis with tricuspid valve insufficiency. Cardiovasc Radiol 1979;2:239–41.
2. Kan JS, Gardner TJ, White RI. Balloon valvuloplasty for the treatment of pulmonary valvular stenosis (abstr). Pediatr Res 1982;16:101A.
3. Kan JS, White RI, Mitchell SE, Gardner TJ. Percutaneous balloon valvuloplasty: a new method for treating congenital pulmonary valve stenosis. N Engl J Med 1982;370:540–3.
4. Pepine CJ, Gessner JH, Feldman RL. Percutaneous balloon valvuloplasty for pulmonic valve stenosis in the adult. Am J Cardiol 1982;50:1442–5.
5. Lababidi Z, Wu JR. Percutaneous balloon pulmonary valvuloplasty. Am J Cardiol 1983;52:560–2.
6. Walls J, Lababidi Z, Curtis J. Operative evaluation of percutaneous balloon pulmonary valvuloplasty (abstr). J Am Coll Cardiol 1984;3:584.
7. Rocchini AP, Kveselis DA, Crowley D, Dick M, Rosenthal A. Percutaneous balloon valvuloplasty for treatment of congenital pulmonary valvular stenosis in children. J Am Coll Cardiol 1984;3:1005–12.
8. Lock JE, Castaneda-Zuniga WR, Bass JL, Foker JE, Amplatz K, Anderson RW. Balloon dilatation of excised aortic coarctations. Radiology 1982;143:689–91.
9. Lock JE, Niemi TA, Burke BA, Einzig S, Castaneda-Zuniga WR. Transcutaneous angioplasty of experimental aortic coarctation. Circulation 1982;66:1280–6.
10. Lock JE, Bass JL, Amplatz K, Fuhrman BP, Castaneda-Zuniga WR. Balloon dilatation angioplasty of aortic coarctations in infants and children. Circulation 1983;68:109–16.
11. Kan JS, White RI, Mitchell SE, Farmlett EJ, Donahoo JS, Gardner TJ. Treatment of restenosis of coarctation by percutaneous transluminal angioplasty. Circulation 1983;68:1087–94.
12. Lock JE, Castaneda-Zuniga WR, Fuhrman BP, Bass JL. Balloon angioplasty of hypoplastic and stenotic pulmonary arteries. Circulation 1983;67:962–7.
13. Ring JC, Kulik TJ, Burke BA, Lock JE. Overdilation of the pulmonary valve anulus with angioplasty balloons in the normal lamb (abstr). Circulation 1983;68(suppl III):III-394.
14. Campbell M, Brock RC. The results of valvotomy for simple pulmonary stenosis. Br Heart J 1955;17:229–36.
15. Engle MA, Holswade GR, Goldberg HP, Lukas DS, Glenn F. Regression after open valvotomy of infundibular stenosis accompanying severe valvular pulmonic stenosis. Circulation 1958;17:862–73.
16. Gilbert JW, Morrow AG, Talbert JL. The surgical treatment of hypertrophic infundibular obstruction accompanying valvular pulmonic stenosis. J Thorac Cardiovasc Surg 1963;46:457–66.
17. Griffith BP, Hardesty RL, Siewers RD, Lerberg DB, Ferson PF, Bahnson HT. Pulmonary valvulotomy alone for pulmonary stenosis: results in children with and without muscular infundibular hypertrophy. J Thorac Cardiovasc Surg 1982;83:577–83.